

# Treatment of Periodontal Pockets With A Diode Laser

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**Background and Objective:** The aim of this study is to examine the long-term effect of diode laser therapy on periodontal pockets with regard to its bactericidal abilities and the improvement of periodontal condition.

**Study Design/Materials and Methods:** Fifty patients were randomly subdivided into two groups (laser-group and control-group) and microbiologic samples were collected. There have been six appointments for 6 months following an exact treatment scheme. After evaluating periodontal indices (bleeding on probing, Quigley-Hein) including pocket depths and instruction of patients in oral hygiene and scaling therapy of all patients, the deepest pockets of each quadrant of the laser-group's patients were microbiologically examined. Afterwards, all teeth were treated with the diode laser. The control-group received the same treatment but instead of laser therapy were rinsed with H<sub>2</sub>O<sub>2</sub>. Each appointment also included a hygienic check-up. After 6 months the final values of the periodontal indices and further microbiologic samples were measured. The total bacterial count as well as specific bacteria, such as *Actinobacillus actinomycetemcomitans*, *Prevotella intermedia*, and *Porphyromonas gingivalis*, were assessed semiquantitatively.

**Results:** The bacterial reduction with diode laser therapy was significantly better than in the control group. The index of bleeding on probing improved in 96.9% in the laser-group, whereas only 66.7% in the control group. Pocket depths could be more reduced in the laser group than in the control group.

**Conclusion:** The diode laser reveals a bactericidal effect and helps to reduce inflammation in the periodontal pockets in addition to scaling. The diode laser therapy, in combination with scaling, supports healing of the periodontal pockets through eliminating bacteria. *Lasers Surg. Med.* 22:302–311, 1998.

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**Key words:** root; scaling; microbiology

## INTRODUCTION

This study examines the long-term effect of combined periodontal treatment with diode laser and scaling, evaluates bacterial reduction in periodontal pockets, and documents changes in periodontal pocket depth prior to, and following, treatment.

So far, conventional methods for treatment

of periodontal disease have not been equally effective in eliminating all types of bacteria. *Actinobacillus actinomycetemcomitans*, especially,

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TABLE 1. Treatment Scheme

	Lased group	Control group
Appointment No. 1	Selection of patients on the basis of periodontal pocket depth; evaluation of periodontal indices; instruction in oral hygiene and tooth brushing; scaling of all teeth.	Selection of patients on the basis of periodontal pocket depth; evaluation of periodontal indices; instruction in oral hygiene and tooth brushing; scaling of all teeth.
Appointment No. 2 after 1 week	Hygienic check-up; microbiologic examination; LASER.	Hygienic check-up; microbiologic examination; rinsing with H <sub>2</sub> O <sub>2</sub> .
Appointment No. 3 after 2 weeks	Microbiologic examination	Microbiologic examination
Appointment No. 4 after 2 months	Hygienic check-up; LASER.	Hygienic check-up; rinsing with H <sub>2</sub> O <sub>2</sub> .
Appointment No. 5 after 4 months	Hygienic check-up; LASER.	Hygienic check-up; rinsing with H <sub>2</sub> O <sub>2</sub> .
Appointment No. 6 after 6 months	Microbiologic examination; measurements of periodontal indices; measurements of periodontal pocket depth.	Microbiologic examination; measurements of periodontal indices; measurements of periodontal pocket depth.

plays a causative role in the development of periodontal disease that has shown to be difficult to eliminate [1].

Since a pilot study on diode laser treatment yielded very favorable results regarding bacterial reduction of *Actinobacillus actinomycetemcomitans*, *Porphyromonas gingivalis*, and *Prevotella intermedia*, this long-term study was carried out to evaluate the bacterial counts in periodontal pockets irradiated with the diode laser over a 6 month period.

Changes in periodontal pocket depth and papillary bleeding index were used as significant parameters in the evaluation of the success of treatment.

## MATERIALS AND METHODS

The patients were randomly subdivided into two groups. Thirty-seven patients were assigned to the group that underwent laser treatment; however, three of them could not be considered in the final evaluation because of inadequate oral hygiene. Thirteen patients were used as controls, one patient dropped out due to illness.

Table 1 illustrates the treatment scheme that determined the different examination and treatment steps. The criterion for inclusion in this study was that at least one periodontal pocket with a depth of at least 4 mm had to be present in each of the four quadrants. All patients were completely dentate. When wisdom teeth were present, they were included in the treatment but excluded from the evaluation.

Measurements of the periodontal indices

were carried out. The papillary bleeding index (PBI) and the plaque index according to Quigley and Hein were assessed and the depth of all periodontal pockets were measured using a special periodontal probe (Ash Parodontic 25G). All measurements were carried out by the same examiner.

To create comparable conditions, the patients were asked to brush their teeth twice daily after meals with a specific toothpaste (Blend-a-med, Procter & Gamble, Schwalbach, Germany) and were instructed in proper oral hygiene. Furthermore, all patients underwent scaling at the first appointment. They were recalled 1 week later for microbiologic sampling. One sample per patient was obtained from the deepest approximal periodontal pocket. The microbiologic samples were obtained using sterile paper tips that were introduced into the periodontal pocket for 10 seconds. The subgingival portion of the paper tip was cut off with a sterile pair of scissors and put into a transport jar containing 1 ml reduced transport fluid without EDTA.

In the lased group, 29.4% of the samples from maxillary periodontal pockets were obtained from the molar region, 11.8% from the premolar region, and 11.8% from the anterior region.

Of the samples from mandibular periodontal pockets 17.6% were obtained from the molar region, 20.6% from the premolar region, and 8.8% from the anterior region.

In the control group, 33.4% of the maxillary samples were obtained from the molar region, 8.3% from the premolar region, and 16.7% from the anterior region, while 25% of the mandibular

samples were taken from the molar region, 8.8% from the premolar region, and 8.3% from the anterior region.

### Microbiologic Evaluation

The total bacterial counts as well as specific bacteria, such as *Actinobacillus actinomycetemcomitans*, *Prevotella intermedia*, and *Porphyromonas gingivalis*, were assessed semiquantitatively.

### Microbiologic Examinations

The samples were first shaken by vortexing for 30 seconds and then diluted 1:100 and 1:1,000 in RTF. One-hundred  $\mu$ l of the undiluted suspension, 100  $\mu$ l of the suspension diluted 1:100 RTF, and 100  $\mu$ l of the suspension diluted 1:1,000 RTF were inoculated on ETSA (enriched trypticase soy agar), TSBV, and KVLB (kanamycin 75  $\mu$ g/ml, vancomycin 2 mg/ml) agar, respectively. ETSA and KVLB agars were incubated with mixed gas (80% N<sub>2</sub>, 10% H<sub>2</sub>, 10% CO<sub>2</sub>) in anaerobic jars for 7 days at 37°C using the evacuation replacement method. TSBV agar was incubated with 10% CO<sub>2</sub> for 5 days at 37°C.

*Actinobacillus actinomycetemcomitans* was identified using gram staining, colony morphology, and positive catalase reaction. *Prevotella intermedia* and *Porphyromonas gingivalis* were identified using gram staining, incubation in 5% CO<sub>2</sub>, BA-NA hydrolytic activity,  $\alpha$ -glucosidase activity, esculin hydrolysis, and Indole test.

The lased group underwent irradiation with the diode laser at the second appointment. Lasing was carried out with a diode laser by Dentek Laser System (Dentek, Gaisfeld, Austria) that has a thin flexible light guide with a diameter of 0.4 mm and a wavelength of 805 nm. All periodontal pockets of all patients of this group were lased at an output power of 2.5 W, a pulse duration of 10 ms, and a frequency of 50 Hz.

Each tooth was subdivided into four quadrants, each of which was lased separately as follows: The light guide was introduced into the periodontal pocket and moved from apical to coronal, parallel along the root surface, in a sweeping fashion. This procedure was carried out in all four quadrants, i.e., buccally, lingually, palatally, and approximally. All teeth were lased in this fashion. The duration of lasing depended on the depth of the respective periodontal pocket. The pocket depth in mm corresponded to the exposure time in seconds. 3-mm-deep pockets were lased for 3 sec-

**TABLE 2. Comparison Between Initial and Final Findings\***

	TC	AAC	Pi	Pg
Lased group				
Better results	100%	73.5%	85.3%	88.3%
Consistent results	0%	0%	0%	6.0%
Worse results	0%	0%	0%	0%
Negative from the start	0%	26.5%	14.7%	5.7%
Control group				
Better results	58.4%	33.3%	58.3%	58.3%
Consistent results	33.3%	16.7%	16.7%	16.7%
Worse results	8.3%	8.3%	0%	8.3%
Negative from the start	0%	41.7%	25.0%	16.7%

\*TC, Total bacterial count; AAC, *Actinobacillus actinomycetemcomitans*; Pi, *Prevotella intermedia*; Pg, *Porphyromonas gingivalis*.

onds, 4-mm-deep pockets for 4 seconds, 5-mm-deep pockets for 5 seconds, and so on.

The control group underwent rinsing with H<sub>2</sub>O<sub>2</sub> at the second appointment, following the microbiologic examination.

At the third appointment after two weeks, the patients of both groups underwent another microbiologic examination, the procedure used being the same as above. The microbiologic samples were obtained from the same periodontal pockets as in the first examination.

At the fourth appointment after 2 months, both groups again underwent an evaluation of the hygienic index. The patients of the lased group again underwent lasering of all teeth as described above.

The fifth appointment after 4 months comprised the same treatment and examination procedures as the fourth appointment.

At the last recall appointment after 6 months, microbiologic samples were again obtained from the same periodontal pockets as before using the same procedure. Furthermore, the same examiner carried out measurements of all periodontal indices and periodontal pocket depth in both groups.

As mentioned previously, some of the patients did not meet minimum oral hygiene requirements (Quigley-Hein Index  $\geq 1$ ) and had to be excluded from the evaluation.

## RESULTS

### Changes in the Bacterial Counts Following Treatment of Both Groups

Table 2 shows a comparison between the initial and the final findings. As far as the total bac-

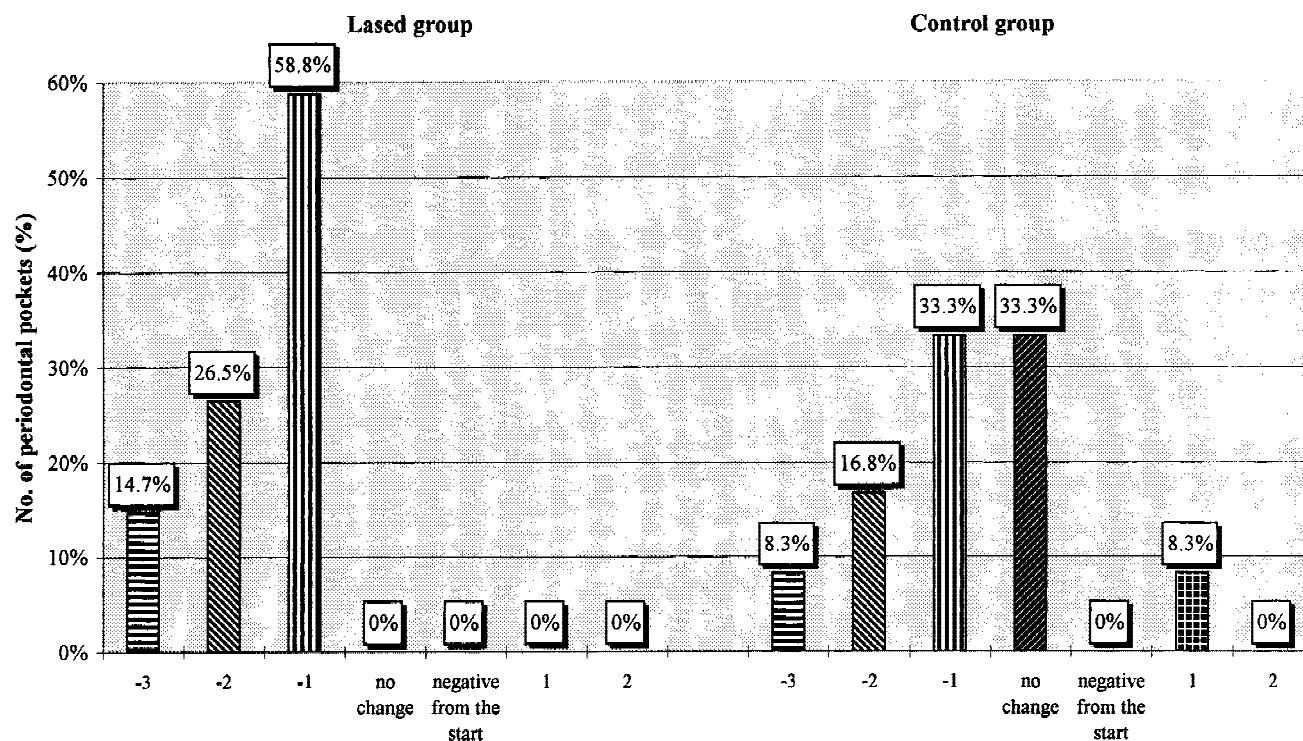


Fig. 1. Changes in total bacterial counts in log steps.

terial count is concerned, long-term bacterial reduction was achieved in the 100% of the lasered patients, whereas 58.4% of the controls showed an improvement of the values, i.e., bacterial reduction, 8.3% a deterioration of the results, i.e., an increase in bacteria in the periodontal pockets, and 33.3% consistent results, i.e., the initial and final values were the same.

The long-term bactericidal effect of the diode laser on *Actinobacillus actinomycetemcomitans* (AAC) is of interest as well. Bacterial reduction of AAC was achieved in 73.5% of the lasered patients; the remaining 26.5% had not been contaminated with this bacterium from the start. In contrast, 33.3% of the controls showed bacterial reduction, 16.7% consistent values, and 8.3% an increase in bacteria. More than 41% of the controls had not shown contamination with AAC from the start.

A reduction in *Prevotella intermedia* (Pi) was achieved in 85.3% of the lasered patients and 58.35% of the controls.

Similar results were obtained for *Porphyromonas gingivalis* (Pg) and are shown in Table 2.

Figure 1 shows a comparison of the reduction in total bacterial counts by logarithmic steps between the lasered group and the control group. It can be seen that 58.8% of the lasered patients un-

derwent bacterial reduction by one log step, i.e., by one power of ten, 26.5% by two log steps, and 14.7% by three log steps. 33.3% of the controls underwent bacterial reduction by one log step, 16.8% by two log steps, and 8.3% by three log steps. In the control group, 33.3% showed consistent results and 8.3% an increase in the total bacterial count by one log step.

Figure 2 shows the changes in the bacterial counts of AAC. A noticeable finding was that 58.8% of the lasered patients showed bacterial reduction by one log step. In comparison, 25% of the controls showed an improvement of the values by one log step. While none of the lasered patients showed worsening of the results, the values of 8.3% of the controls deteriorated by one log step.

As far as Pi is concerned, 41.2% of the lasered patients underwent bacterial reduction by one log step, 35.3% by two log steps, 5.9% by three log steps, and 2.9% by four log steps. Over 58% of the controls showed an improvement of the results by one log step (Fig. 3).

Figure 4 shows the changes in the bacterial counts of Pg. 47.1% of the lasered patients underwent a reduction in the bacterial count by one log step, 26.5% by two log steps, and 14.7% by three log steps, whereas 41.6% of the controls showed a reduction in Pg by one log step and 16.7% by two

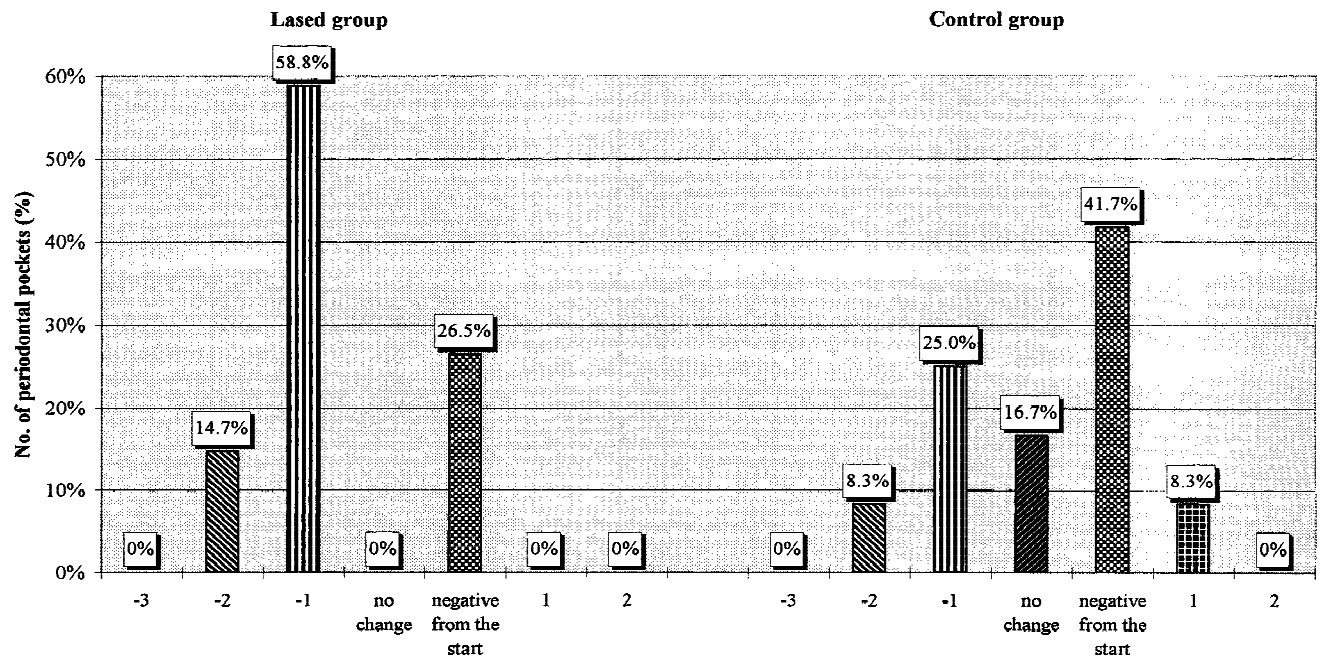


Fig. 2. Changes in AAC in log steps.

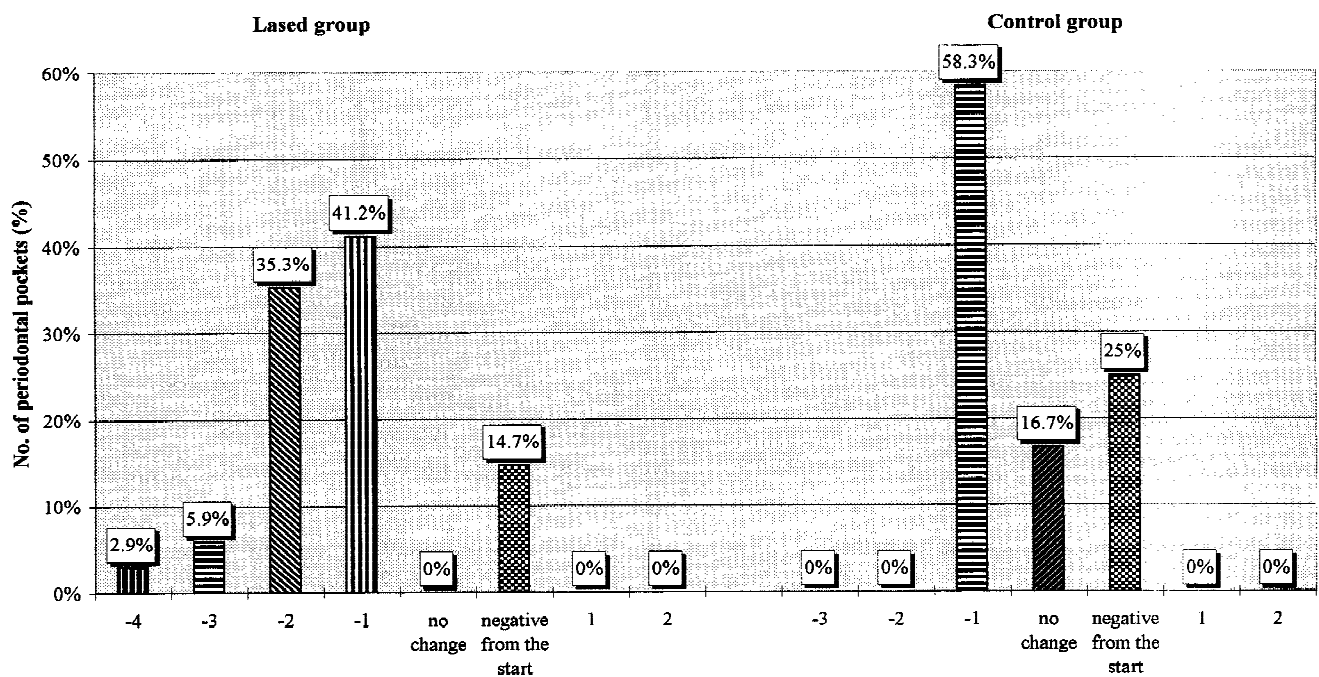


Fig. 3. Changes in Pi in log steps.

log steps. Consistent results were seen in 16.7% and in 8.3%, a deterioration of the results by two log steps.

Figure 5 illustrates the changes in the pap-

illary bleeding index (PBI). The values improved in 96.9% of the lased patients and remained the same in 3.1%. PBI improved in 66.7% of the controls and remained consistent in 33.3%.



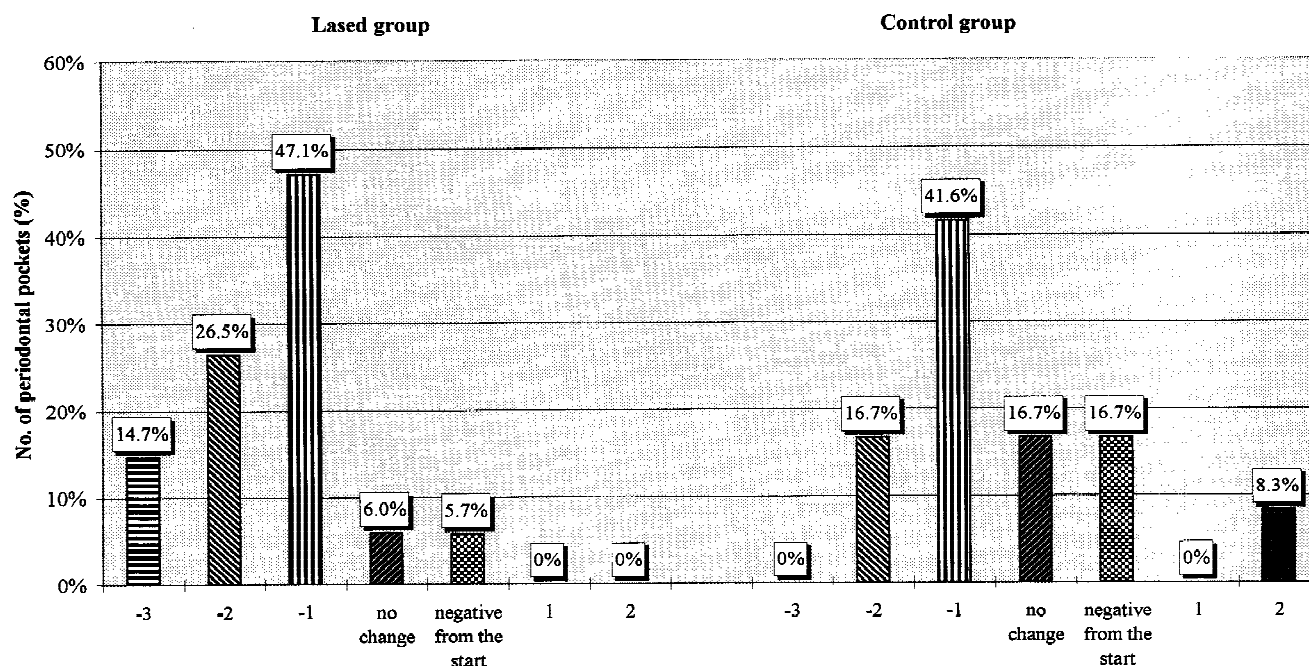


Fig. 4. Changes in Pg in log steps.

Figure 6 shows the changes in the depth of all approximal periodontal pockets for both the lased and the control groups. The teeth were subdivided into anterior teeth, premolars and molars

to facilitate a better comparison. Figure 6 clearly shows that the number of periodontal pockets whose depth decreased in comparison to the initial value was markedly greater in the lased

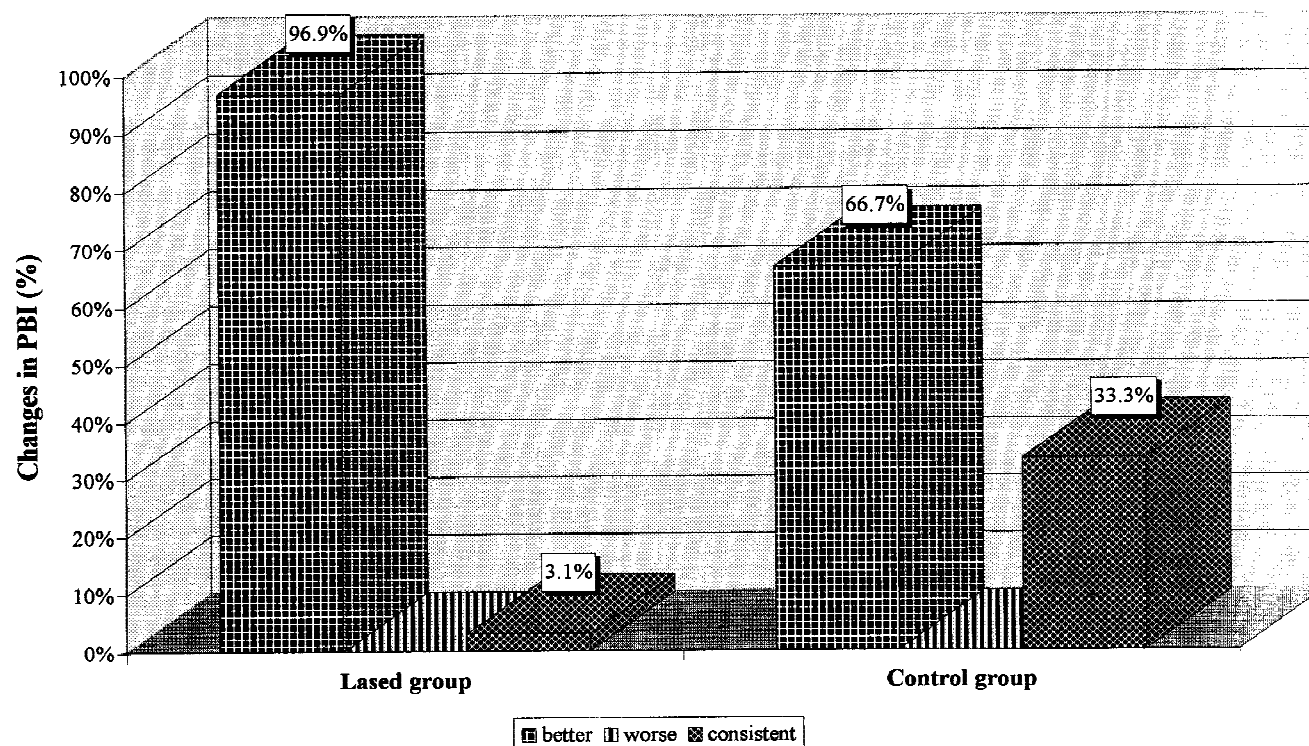


Fig. 5. Changes in PBI.

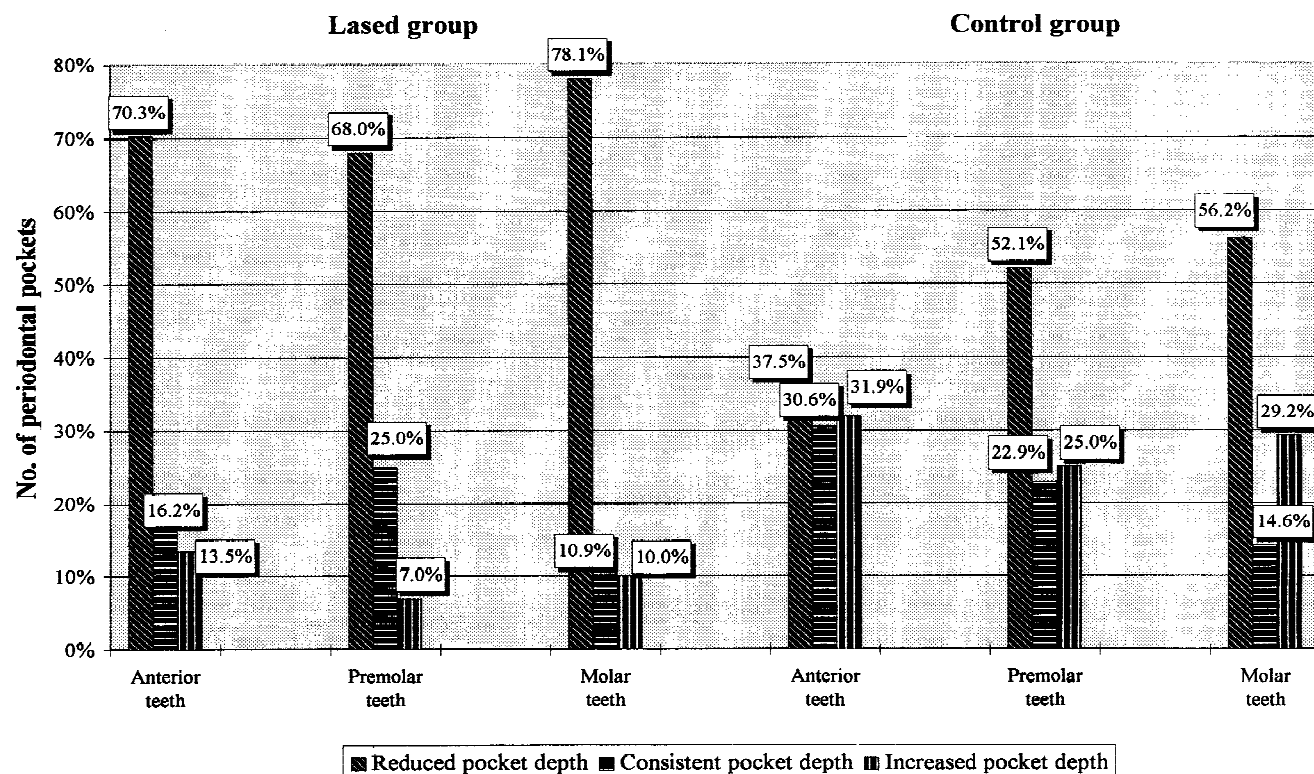


Fig. 6. Changes in pocket depth.

group than in the control group. The control group, on the other hand, showed more periodontal pockets with an increased pocket depth than did the lased group.

Figure 7 allows a comparison of the mean periodontal pocket depths, showing the initial and final values separately for the anterior, premolar, and molar regions, as well as a comparison between the lased group and the control group.

In the lased group, the mean periodontal pocket depth decreased from 3.9 mm to 2.6 mm, especially in the molar region. Furthermore, the mean periodontal pocket depth in the premolar region decreased by 1 mm in this group. In the anterior region, the values decreased from 2.5 mm to 1.6 mm.

In the control group, the mean initial periodontal pocket depth in the molar region was around 3 mm and decreased to 2.6 mm after 6 months. The periodontal pocket depth in the premolar and molar regions was reduced by 0.1 mm and 0.2 mm, respectively.

## DISCUSSION

Most publications dealing with laser treatment of periodontal tissues cover the usage of the

Nd:YAG laser. However, we expect the diode laser to have similar properties as the Nd:YAG laser that emits radiation within the infrared range at a very similar wavelength.

The effect of laser irradiation on certain tissues depends on both the wavelength of the laser and the absorbing capacity of the lased tissue. A study by Gold et al. [3] demonstrated that the application of the Nd:YAG laser for curettage of the pocket epithelium does not cause damage to the underlying tissue layers. Histologic sections revealed complete removal of the pocket epithelium without necrosis and carbonization of the connective tissue structures in 83% of the cases.

A theoretical paper by Rastegar et al. [4] comparing the application of a high-power diode laser (810 nm) and a Nd:YAG laser (1,064 nm) for tissue coagulation showed that both lasers had similar effects.

However, the heat building up at a depth of 0.2 cm in the prostatic tissue of a dog during irradiation with a diode laser was almost 1.5 times that caused by the Nd:YAG laser. This means that the diode laser radiation was absorbed mainly by the superficial prostatic layers.

Because desmodontal tissue is very well sup-

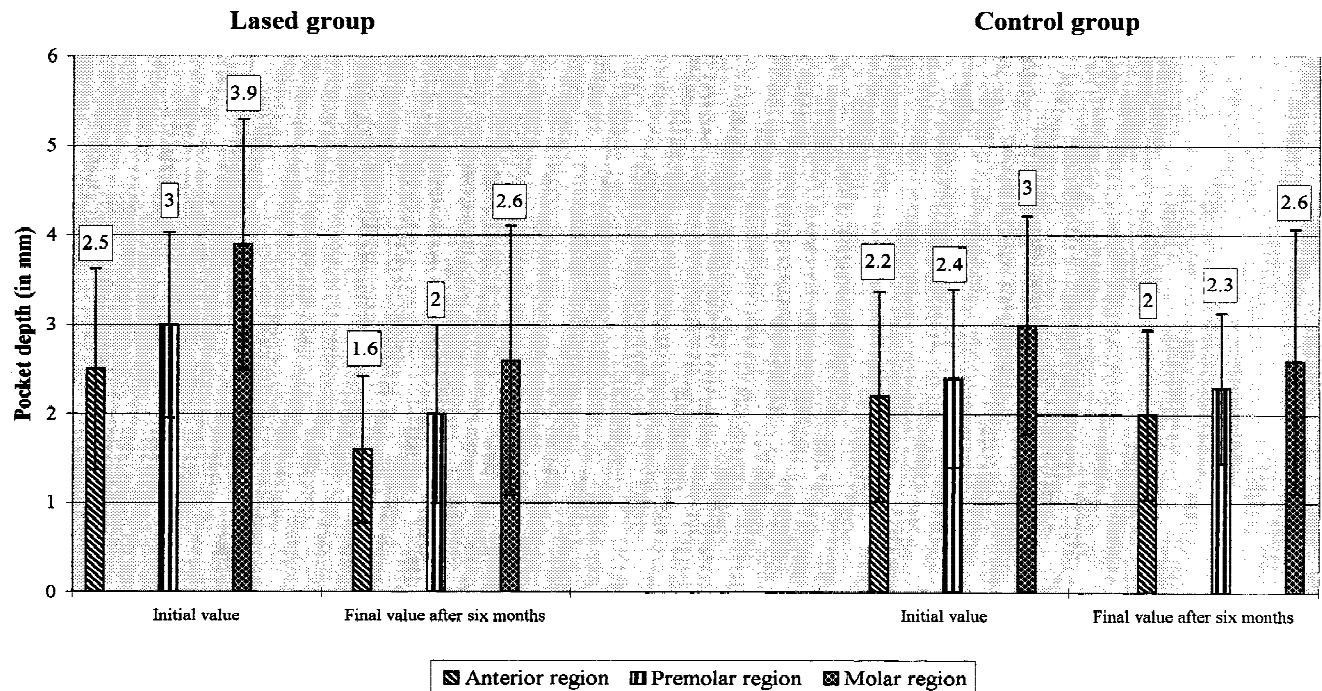


Fig. 7. Comparison of mean pocket depths.

plied with blood, it is of interest to see to what extent diode laser radiation is absorbed by blood. Rastegar et al. [4] examined the absorption of laser radiation by oxygenated and deoxygenated blood and found an absorption of  $4.5 \text{ cm}^{-1}$  and a penetration of 2.2 mm in both. A comparison of the absorption values of other tissues examined in that study (liver, heart, prostate) revealed that the greatest absorption occurs in oxygenated and deoxygenated blood. It can thus be concluded that tissue that is very well supplied with blood too shows a high absorbing capacity.

Morlock et al. [5] observed melted and resolidified porous globules consisting of root mineral substance at the root surface following Nd:YAG laser treatment. The impressions in the root cementum had a mean depth of 20–30  $\mu\text{m}$ . Infrared spectroscopic examinations carried out by Spencer et al. [6] revealed a decrease in the protein/mineral ratio of the root surface following Nd:YAG laser treatment. Cobb et al. [7] reported a significant reduction in periodontopathic bacteria. However, the cementum surface was damaged by the high energy levels of 1.75 W and higher in vivo. Ineffective and patchy removal of deposits on the root surface was observed that was associated with areas of cratering and melt-down. Wilder-Smith et al. [8] were able to eliminate the smear layer on root-planed surfaces

without inducing hard tissue microstructural damage. The intra-pulpal temperature increased to  $22^\circ\text{C}$  and the surface temperature to  $36^\circ\text{C}$ . Zach and Cohen [9] found that a temperature rise as small as  $5.5^\circ\text{C}$  can damage pulpal vitality.

Horton and Lin [10] indicated that subgingival application of the pulsed Nd:YAG laser should be at least equally effective in reducing recolonization of specific bacterial species as scaling and root planing, less effective in removing calculus, and without any difference regarding measurements of probing depth and attachment loss.

According to Radvar et al. [11], Nd:YAG-laser-induced damage to the root surface also depends on the treatment method used. Only when the laser beam is guided parallel to the root surface it does not cause damage to the root, whereas perpendicularly applied laser radiation damages the root surface.

As far as bacterial reduction in periodontal pockets is concerned, the diode laser is expected to have a disinfecting thermal effect on bacteria that is basically limited to the root surface. The thermal effect of the laser beam is based on the absorption of radiation by tissue and subsequent transformation of laser energy into heat. Tissue absorbs a certain amount of laser radiation per volume and transforms it into a certain amount of energy, depending on the exposure time used. The



amount of energy absorbed depends on the type of tissue irradiated and the wavelength of the laser.

The diode laser is not expected to cause damage to the pulp when operated in pulsed mode and at an output power of 2.5 W since White et al. [12] described only a negligible temperature rise within the pulp during irradiation with a Nd:YAG laser.

Laser light is supposed not only to eliminate bacteria but also to inactivate bacterial toxins diffused within root cementum [13].

However, recent studies by Radvar et al. [10] examining the irradiation of periodontal pockets with the Nd:YAG laser at a pulse energy of 80 mJ and 50 mJ revealed no significant bacterial reduction in periodontal pockets following laser treatment. Tseng and Liew [14] observed a significant reduction in bacterial counts; complete inhibition of all anaerobes was observed in teeth lased at output powers greater than 1 W and 20 pps.

The wavelength of their lasers ranged around 1,064 nm. Although the Nd:YAG laser is similar to the diode laser, it leads to a temperature rise in markedly deeper tissue layers, whereas most of the diode laser radiation is absorbed by superficial layers, thus having a better effect on sites affected by periodontal disease. However, the actual mechanisms of all possible laser bacteria interactions still have to be scrutinized.

The effectiveness of scaling and root planing in the treatment of periodontal disease to reduce bacterial plaque on the root surface is universally accepted [15]. Sbardone et al. [16] reported that diseased sites treated with a single episode of scaling and root planing exhibited a microflora similar to that in healthy sites at 7 days after treatment. However, the treated sites were repopulating with potentially pathogenic microbes at 21 days after treatment. Lin et al. [17] indicated that subgingival treatment with the Nd:YAG laser without anesthesia is more effective in reducing or inhibiting recolonisation of Actinomyces for up to 28 days than is root planing.

In the present study, the diode laser was used as supplementary treatment aimed to reduce or eliminate bacteria but not for calculus removal or pocket curettage. Observations at 7 days after laser treatment without scaling and root planing showed early recolonization by a variety of microbial morphotypes [7]. Lin et al. [18] showed that subgingival use of the Nd:YAG laser is less effective in removing calculus than is root planing.

Because the effects of laser treatment on periodontal tissue basically depend on the wavelength, pulse energy, frequency, and spot size used, we consider the diode laser an interesting alternative to conventional IR lasers in periodontal treatment. Furthermore, lasing is a treatment modality that is finding very good acceptance with patients because it involves minimal pain.

## REFERENCES

1. Renvert S, Wilkström M, Dahlen G, Slots J, Egelberg J. Effect of root debridement on the elimination of *Actinobacillus actinomycetemcomitans* and *Bacteroides gingivalis* from periodontal pockets. *J Clin Periodontol* 1990;17:345-350.
2. Quigley GA, Hein JW. Comparative cleaning efficiency of manual and power brushing. *J Am Dent Assoc* 1962;65: 26-29.
3. Gold SJ, Vilardi MA. Effect of Nd:YAG laser curettage on gingival crevicular tissues. *J Dent Res* 1992; 71:299 (abstract 1549).
4. Rastegar S, Jacques SL, Motamedi M, Kim B-M. Theoretical analysis of equivalency of high-power diode laser (810 nm) and Nd:YAG laser (1064 nm) for coagulation of tissue: Predictions for prostate coagulation. *SPIE Vol. 1646 Laser-Tissue Interaction* 1992; 150-160.
5. Morlock BJ, Pippin DJ, Cobb CM, Killoy WJ, Rapley JW. The effect of Nd:YAG laser exposure on root surfaces when used as an adjunct to root planing: An in vitro study. *J Periodontol* 1992; 63/7:637-641.
6. Spencer P, Trylovich DJ, Cobb CM. Chemical characterization of lased root surfaces using fourier transform infrared photoacoustic spectroscopy. *J Periodontol* 1992; 63:633-636.
7. Cobb CM, McCawley TK, Killoy WJ. A preliminary study on the effects of the Nd:YAG laser on root surfaces and subgingival microflora in vivo. *J Periodontol* 1992; 63: 701-707.
8. Wilder-Smith P, Arrastia A-M, Schell MJ, Liaw LH, Grill G, Berns MW. Effect of Nd:YAG Laser irradiation and root planing on the root surface: Structural and thermal effects. *J Periodontol* 1995; Vol 66/12:1032-1039.
9. Zach LO, Cohen G. Pulp. Response to externally applied heat. *Oral Surg Oral Med Oral Pathol* 1965; 19:515-530.
10. Horton JE, Lin PP-y. A Comparison of the Nd:YAG Laser Used Subgingivally With Root Planing. 3rd International Congress on Laser in Dentistry, Salt Lake City, Utah, August 6-8, 1992, Page 23, Abstract 46.
11. Radvar M, MacFarlane TW, MacKenzie D, Whitters CJ, Payne AP, Kinane DF. An evaluation of the Nd:YAG laser in periodontal pocket therapy. *Br Dental J* 1996; 180/ 2:57-62.
12. White JM, Goodis HE, Rose CM. Nd:YAG pulsed infrared laser for treatment of root surface. *CDA J* 1991; 55-58.
13. Pick RM, Pecaro BC, Silberman CJ. The laser gingivec-

- tomy. The use of the CO<sub>2</sub> laser for the removal of phenytoin hyperplasia. *J Periodontol* 1985; 56/8:492–496.
14. Tseng P, Liew V, The bactericidal effect of Nd:YAG laser: Preliminary in vitro studies. *Periodontology* 1992; 13(1): 20–25.
15. Badersten A, Nilveus R, Engelberg J. Effect of nonsurgical periodontal therapy. II Severely advanced periodontitis. *J Clin Periodontol* 1987; 10:63–73.
16. Sbardone L, Ramaglia L, Gulletta E, Iacono V. Recolonization of subgingival microflora after scaling and root planing in human periodontitis. *J Periodontol* 1990; 61: 579–584.
17. Lin PP, Rosen S, Beck FM, Matsue M, Horton JE. The effect of a pulsed Nd:YAG laser on periodontal pockets following subgingival application. *J Dent Res* 1992; 71: 299 (abstract 1548).
18. Lin PP, Rosen S, Beck FM, Matsue M, Horton JE. A comparative effect of the Nd:YAG laser with root planing on subgingival anaerobes in periodontal pockets. *J Dent Res* 1992; 71:299 (abstract 1547).